RELATIVE HUMIDITY AND FOREST FIRES.

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Fire is a natural phenomenon and is controlled by natural factors. Various factors of the atmosphere such as air pressure, temperature, precipitation, wind movements, electrical condition, and humidity, all have been studied in their relation to forest fires. Other factors, however, have also been considered. For example, experiments have shown that fires will burn more rapidly uphill than on level ground.[1] Man himself has been a factor of major significance. He is both actively and passively concerned. The environmental factors are beyond his control. But he is responsible for most of the fires, and he frequently adjusts himself differently in areas which have been burned over than in similar unburned regions.

Of the meteorological elements mentioned above, some are especially significant in their relation to forest fires. Winds, high temperature, and low humidity, either singly or in combination, are particularly effective in producing a high fire hazard.[2] The element, however, that seems to claim the distinction of being the controlling factor in fire hazard is relative humidity. Temperature and wind only accentuate the influence of low relative humidity. "Humidity is now recognized as being of special significance in connection with the starting and spread of forest fires. It is being studied perhaps more intensively than any other factor connected with the problem."[3]

Relation of relative humidity to temperature, winds, and precipitation.—Owing to the fact that temperature, winds, and precipitation are important factors in connection with the fire hazard, they are frequently given a place of undue importance.

Experiments have shown that high temperatures may occur during periods of high relative humidity and con-

[1]Osborne, W. B. Jr., 1925. "Primary factors governing action of forest fires." The Timberman. Vol. 26, 190.

[2]Norquist, C. E. 1925. "Weather conditions as related to fire control." The Timberman, 26:132.

[3]Calvert, E. B. 1925. "Weather forecasting as an aid in preventing and controlling forest fires. Monthly Weather Review, 53:187.

sequently have no drying effect.[4] An extreme fire hazard, however, will exist during periods of low temperature if the humidity is low.[5] The common belief that high temperatures cause rapid evaporation is simply a result of the fact that we usually have a comparatively low relative humidity when temperatures are high. Occassionally, however, we have high temperatures and high relative humidity. Under such conditions the materials of the forest are not highly inflammable, and instead of evaporating may be actually absorbing moisture from the atmosphere. Of course, temperature is one of the components of relative humidity; but if we know the relative humidity we have already taken into account the effect of temperature.

It is a well established fact that strong winds may occur during periods of low as well as high relative humidity. Hence, a strong wind may actually extinguish a fire if it brings in air which contains much moisture. A strong wind, on the other hand, occuring during a period of low humidity causes the most serious combination of factors. "All of the great historic forest fires have occurred during periods of low relative humidity. In a few cases the wind was extremely high, but in the great majority of cases, the records show that the winds were not at all abnormal."[6]

The author has observed in northern Wisconsin (1) that forest fires would die down under increasing winds when those winds were carrying in moisture-laden air, and (2) that winds lose their velocity a short distance within a stand of heavy timber. The latter may be substantiated by experiments conducted at the Wind River Experiment Station. An anemometer operated for an entire season at the Wind River Station and located 200 yards inside of a dense stand of mature timber failed to show any wind velocities of over two miles an hour, although velocities of 15-20 were frequently recorded a short distance out in the adjacent burn.[7]

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[4]Hofmann, J. V. and Osborne, Wm. B. Jr.: Relative Humidity and Forest Fires, 5.

[5]*Ibid*, 25:57.

[6]Hofmann, J. V.: "Relative Humidity and forest fire prevention and control." The Timberman, 25:56.

[7]Osborne, W. B. Jr. "Primary factors governing action of forest fires." The Timberman, 26:190.

Fire fighters have observed that under similar burning conditions a fire located on a steep slope and without wind will burn uphill nearly as fast as a similar fire would spread on level ground and backed by a moderately strong wind. This fact becomes extremely significant in areas where the timber is located on steep slopes.[8]

Winds, however, are of great significance to foresters in some parts of the country. Mr. Beals, of the weather bureau service, found that there was a definite relationship between easterly winds and forest fires west of the Cascade Mountains. Furthermore, he has studied the ways in which forest fires may create their own winds.[9]

A deficiency of rainfall does not necessarily indicate a fire hazard, but a forest area is well protected as long as the relative humidity remains high. The effect of rains is not a lasting one. Rains make the forest safe from fire for only a short time if periods of low humidity occur. "The ameliorating effects of precipitation are immediate and, within limits, are directly proportional to the amount. However, the dampening effects of light rains on forest materials under the shelter of heavy stands of timber are negligible and the effect of moderately heavy rainfall is somewhat dissipated in a surprisingly short time."[10]

The relation of relative humidity to fire fuels.—The relationship of relative humidity to forest fires is established through the fire fuels or forest litter upon which the fire feeds. Forest fuels consist of needles, branches, twigs, windfalls, bits of bark, moss, grass, etc.

Relative humidity, being the percentage of saturation of the air, largely governs its absorbing and evaporating power. Consequently the relative humidity is the greatest factor in controlling the moisture content of those forest fuels which are directly exposed to the air and determines the degree of their inflammability. The inflammability of the forest fire materials is the most important factor which controls the fire hazard. Since relative humidity has a direct bearing on the degree of inflammability, and since

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[8] *Ibid.*

[9] Beals, E. A. "The value of weather forecasts in the problem of protecting forests from fire." Monthly Weather Review, 42:111-119.

[10] Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26:132.

this can be determined, a record of relative humidity therefore can be used as an indicator of the fire hazard.[11]

The inflammability point for the various fuels is not the same. Light fuels such as moss and dead weeds may be dry enough to ignite with a match; while twigs, duff, and branchwood are too wet to burn. Light fuels such as fern, firewood and pearly everlasting have shown very rapid changes in moisture content with changes in relative humidity. Thus where those materials occur in abundance, hourly and daily records are very significant. Records show that a period of humidity of 35 per cent or lower for only one day will cause a fire hazard in open areas of fern, firewood, pearly everlasting and other weeds and grasses in the early spring before these dead materials are covered by a new growth of weeds, grasses, and shrubs.[12]

In some areas the light fuels are the ones which deserve the most careful attention. C. S. Cawan says: "If the logging operator can get rid of the light material, such as twigs, needles, and splintered debris, on the ground, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from the carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark; it must be dried and set alight by the flame and heat from the smaller material or kindling before it becomes a source of danger."[13]

J. T. Gisborne has shown the importance of duff moisture content in the forest fire problem. He found that in most of the valuable timber of northern Idaho the top quarter to half-inch layer of duff exhibits the effects of weather elements as they affect dryness and inflammability in the forest. Top layer duff picks up or loses moisture about as the average important fuel in this type, and is itself one of the most important receivers and carriers of fire.[14]

Air-dry litter is marked by deliquescent, that is, it takes up moisture from the air, independently of precipitation. And even during the hot season it takes up from 5 to 6 per cent of its own air-dry weight every night. This ex-

[11]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires, 1."

[12]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires, 6."

[13]Cawan, C. S. "The loggers hazard in its relation to fire weather." The Timberman 26 No. 9:134. °

[14]Gisborne, J. T. "The importance of duff moisture content in the forest fire problem." Journal of Forestry, 21:809.

plains to a very large extent the well-known fact that fires burn more slowly by night than by day.

Not only kind of forest material but amount as well should be taken into account when calculations of the danger point are made from relative humidity records. For example, in western Washington the hazardous point is reached when the relative humidity falls 35 or below, whereas in eastern Washington, the hazardous point is not reached until the relative humidity falls to 20 or below. The difference is explained by the fact that forest growth and underbrush are not as dense in the pine region of eastern Washington as in the fir region of western Washington. Hence there is much less inflammable debris present.[15]

Experimental evidence of the relationship of relative humidity to forest fires in various parts of the country.— The above records from Washington, indicate that the danger point varies from one part of the country to another, and variation is closely related to the kinds of forest materials which are found.

Studies conducted by the Wind River Forest Experiment Station on the effect of relative humidity on forest fires showed that fires did not spread when the relative humidity was above 60 per cent. That they spread very slowly and only in very favorable material when the relative humidity was between 50 and 60 per cent. When the humidity was between 40 and 50 per cent fires picked up, varying from a few running fires to fires that smoked up and did not spread. With a humidity of 30 to 40 per cent, fires gained some headway and some rapidly spreading fires occurred. A humidity below 30 per cent caused fires to spread beyond control. Crown fires occurred when the humidity dropped to 25 per cent or lower.[16]

In Connecticut, records of the number of fires per day for the years 1922, '23, and '24, show that there were less than ten fires per day when the relative humidity was between 60 and 70; about 15 per day when the relative humidity was between 50 and 60; and over 30 per day when the relative humidity was between 40 and 50 per cent.[17]

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[15]Cronemiller, L. F. "Relative humidity and forest fires." The Timberman, 26, no. 5:64.

[16]Hofmann, J. V. "Relative humidity and forest fire prevention." The Timberman, 25, No. 1:56-58.

[17]Moss, A. E. "Forest fires and weather." Journal of Forestry, May, 1926, 556.

In Idaho a study of the records in connection with 192 man-caused fires shows that 62 per cent of them occurred on days when the relative humidity had fallen to 20 or below, and 30 per cent of them when the humidity lay between 20 and 30 per cent. It therefore appears that the danger of fire from matches, cigars, and cigarette butts, is not high when the humidity remains above 30 per cent, is fairly high when the humitity is between 20 and 30 per cent, and is very high when the humidity falls below 20 per cent.[18]

Strikingly significant is the record kept of the great Berkeley fire. This fire destroyed over 50 square blocks of dwellings in the city of Berkeley, the seat of the University of California. At 5 o'clock on the 17th of September, 1923 there was a sudden rise of over 60 per cent in the relative humidity, and the fires in the city, which had seemed uncontrollable, were extinguished in a short time.[19]

Application of relative humidity records.—Thus far we have seen the importance which relative humidity possesses as a factor in relation to forest fires. It remains for us to note the more favorable adjustments which may be made to check the fire hazard.

Definite knowledge in regard to the inflammability of forest materials as indicated by the relative humidity of the present moment, is of inestimable value in all phases of protection and suppression work.

The following adjustments to meet the fire situation are worthy of careful consideration.

1. The smoldering fires must be put out immediately, while they are small, when they can be handled at small expense and before conditions change.

2. Slash burning should be performed when the relative humidity is high, and all fires should be extinguished immediately when the relative humidity is low. Spring is the best time in which to dispose of slash, because the slash is dry enough to burn in the spring while the lower layers of duff still contain sufficient moisture to protect the

[18]Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26, No. 9:132.

[19]Alexander, Geo. W. "Weather and the Berkeley fire." Monthly Weather Review, 51:464.

seed that is stored in the forest floor from the heat of the fire.

3. Burn first near rights-of-way. It is not the custom or habit of human beings to wander through a slash area when they can follow an old trail. This means that the danger from fire, which is largely a man-caused one, is not very far from the rights-of-way or trails.

4. Burn the light materials. If the logging operator can get rid of the light material, such as twigs, needles and splintered debris, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from a carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark.

5. A greater number of hygro-thermographs, hygrographs, or sling psychrometers should be distributed throughout the forest areas so that more careful records may be kept of relative humidity, the important factor in forest-fire control.

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